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(54) Method and Arrangement for Contactless Axle Measurement on Motor Vehicles

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Method and Arrangement for Contactless Axle Measurement on Motor Vehicles

Scope of the Invention

The invention falls into the area of diagnostics of motor vehicles and is to be applied to the measurement of the geometry of wheel axles and steering.

Technical Background

A precise alignment of the wheel axles, especially the front axles, is of decisive importance for driving safety and driving comfort. This alignment must be checked regularly with test equipment. Testers known per se are available for this purpose. Camber, tow-in, negative and positive caster, steering axis inclination, tow-out on turns and the scrub radius can be determined with these testers. These variables are largely determined by the spatial position of the wheel suspension (steering axis) and of the wheel plane, relative to each other, or relative to the vertical or horizontal reference planes.

The testers required to determine the above-mentioned variables are based on mechanical, optical, opto-mechanical or electronic test methods ("Wissenschaftliche Zeitschrift" [Scientific Journal) of the Technical University of Dresden, 1968, pages 923 – 941; the magazine "Werkstattechnik" [Workshop Technology], 1979, pages 12 – 14; the magazine "Krafthand", 1979, page 608). Optical testers are commonly used. These work with a mirror which is adjusted on the respective wheel axle. In order to be able to evaluate the test results automatically, a known method is to reflect the light beam directed toward the mirror to the light-sensitive layer of a TV recording device. By evaluating the video signal, the position of the picture element is detected, and thus the desired measurement signal is obtained (DE-OS 23 53 965).

It is also a generally known method to evaluate TV signals electronically to automate measurement and control processes. For example, measuring TV systems operating in the visible spectral range or in the infrared or ultraviolet range can be used for length, width and height measurements, for the determination of the position of static objects or the identification and measurement of one or several points having a certain brightness level. Likewise, complicated conversions by means of a small computer equipped with several microprocessors or in connection with mainframe computers are possible. The linking of the measurement process with such computer operations, for example, is necessary if three-dimensional processes are to be recorded. This is possible with the aid of two TV cameras wherein the signals of both TV cameras are evaluated according to the rules of trigonometry (advertising material "Measuring TV Systems" from Hammamatsu company.

Disclosure of the Invention

a) Object of the Invention

The object of the invention is to create a method and an arrangement to collect the data of the wheel axles and of the steering geometry of the motor vehicle, allowing a measurement without contact and adjustment as well as a fully automatic display of the data.

b) Means for Attaining the Object of the Invention

As the means for attaining the object of the invention, the invention is based on a method with which an image dependent on the wheel position is generated on the light-sensitive layer of a TV pick-up tube and the generated image is evaluated electronically. According to the invention, the measurement method requires the following steps:

a. An elliptical image of the circle corresponding to the outer rim diameter of each wheel or a circle arranged concentrically relative to it and mounted on the wheel rim is generated on the light-sensitive TV pick-up tube;

b. the large and the small diameter of the ellipsis, as well as the spatial position of the diameter and its intersection are determined by means of an electronic evaluation of the image signal from the TV pick-up tube;

c. in sequence with the same wheel position and possibly with a changed wheel position varying elliptical images of the circle are generated and the image generated in each case is evaluated electronically;

d. as a result of the measurement results obtained in sequence as well as by taking into account familiar mathematical relationships, the spatial positions of the wheel plane and of the steering axis are determined electronically and the data of the wheel axle and of the steering geometry are determined from the respective data as well as the stored positional data from the TV pick-up tube and the wheel dimensions.

The invention is based on the consideration that the wheel plane of the respective wheel to be measured circumscribes the generated surface of a cylinder, a cone or a hyperboloid of revolution with each steering movement, depending on the position of the steering axis, and that the large diameter of the elliptical image of the circle corresponding to the rim diameter in each case forms a surface line or a tangent at the rotation body. Based on the conic section geometry as well as the circle-ellipsis affinity, for this reason both the axis of the rotation body and thus the spatial axis of the wheel suspension, i.e. the steering axis as well as the spatial position of the wheel plane can be determined from the various positions of the wheel, and the data of the wheel axles and the steering geometry can be calculated from the mutual coordination or the coordination relative to the vertical and horizontal reference planes.

c) Advantages

The special advantage of the new measurement method is that no elaborate adjustment work is required to carry out the measurement, that an exact positioning for the vehicle is not necessary, that in principle no aids have to be mounted on the vehicle and that all desired test data can be determined, displayed and stored by means of electronic equipment.

d) Additional Embodiments

When implementing the new measurement method it is advisable to make use of the known arrangement in the case of which alongside the longitudinal axis of the motor vehicle a TV camera is mounted and on which the electrical parts of the TV camera are connected electrically with an electronic image evaluation device. To adapt this arrangement to the new measurement method the further development of the invention calls for the mounting of a horizontally swivelable and a vertically displaceable TV camera on each side of the motor vehicle, the optical axis of which encompasses an angle of about 45° or more with the respective wheel plane when projecting into a horizontal plane.

The swivelable and displaceable embodiment of the TV camera makes sure that the same wheel position can be recorded from two different viewing angles of the camera and that only one camera on each vehicle side is necessary to observe the rear wheel and the front wheel. The geometric coordination of the camera relative to the vehicle thus makes sure that the circle of the respective wheel corresponding to the rim diameter is represented as an ellipsis on the TV pick-up tube and that the data of the ellipsis can be recorded more precisely the greater the angle between the optical axis of the TV camera and of the wheel axle.

The above-mentioned arrangement with one swivelable and one displaceable TV camera at each vehicle side can be modified in that instead of one vertically displaceable TV camera two vertically stationary TV cameras are provided. In the same manner, the swiveling of the TV camera – which is necessary in order to be able to record the front wheel and the rear wheel – can be replaced by two horizontally stationary cameras. To the extent both measures are to be implemented jointly, accordingly four TV cameras can be mounted on each vehicle side, of which two are corresponding to one front wheel and one rear wheel respectively.

However, the spatial arrangement of each TV camera on one vehicle side and the spatial coordination relative to the front and rear wheel can also be chosen in such a way that on each side of the motor vehicle a TV camera is mounted with one tilted mirror displaceable in its optical axis or with two tilted mirrors arranged in a row in its optical axis, of which the mirror near the camera can be folded out of the optical axis, and that the tilted mirror or mirrors are rotatable individually or jointly around the optical axis of the TV camera in such a way that the optical axis of the TV camera reflected by the tilted

mirrors encompasses an angle of about 45° or more with the respective wheel axle when projecting into a horizontal plane. In this case the observation is shifted from the front wheel to the rear wheel by swiveling the tilted mirror or the tilted mirrors corresponding to the TV camera, if necessary together with the TV camera, while the vertical displaceability of the TV camera is simulated with the aid of the tilted mirrors which themselves are either displaceable in height or are mounted at different levels. In the process the mirror of the TV camera near the camera conveys a different image of the wheel to be observed than the mirror away from the camera.

With such an embodiment of the TV camera with one or two tilted mirrors it may be advantageous for the purpose of improving the test results if the camera together with the tilted mirrors is rotatable around the optical axis of the camera incrementally by small angles, for example an angle of about 1°. If necessary, it is recommended, irrespective of the above, to embody an adjustable deflection angle of the tilted mirrors by increments of small angles, for example an angle of about 1°.

One or several TV cameras can be located on the side of the longitudinal axis of a motor vehicle in such a way that the front and rear wheel can be observed together from the front or the rear. However, this has the disadvantage that the distance between the TV camera and the front wheel is not equal to the distance between the TV camera and the rear wheel. For this reason it is advantageous to mount the TV camera(s) on each side of the motor vehicle more or less in the middle between the front axle and the rear axle. The sizes of the elliptical images of the front and rear wheel are then about equal.

When applying the new measurement method it may be of further advantage in each case if not the complete elliptical image of a circle corresponding to the rim diameter but only a portion of the ellipsis is observed and measured. For this purpose it is recommended to equip the respective TV camera with automatically exchangeable lenses of varying focal points or with a zoom lens. Furthermore, with respect to the accuracy of the measurement, it may be advantageous if the respective TV camera and/or the tilted mirrors are provided with a precision positioning device acting in a horizontal or vertical plane.

In connection with the invention, a measurement method with which the respective wheel is illuminated with a laser beam line by line and the reflected light is received and the received light signal together with pulses controlling the laser beam is electronically evaluated is regarded as a technically equivalent means for attaining the object of the invention. With a corresponding arrangement to implement this equivalent measurement procedure, each TV camera would be replaced with a laser tube with a laser beam deflection system and a light-sensitive diode oriented toward the respective wheel.

e) Exemplary Embodiments

The new measurement method is explained in greater detail on the basis of the exemplary embodiments of an arrangement for the implementation of the method shown in figures 1 through 3 and on the basis of the diagrams shown in figures 4 through 7.

Figure 1 shows a schematic representation of the chassis of a motor vehicle. The front wheels 1 and 2 are mounted on its front axle and the wheels 3 and 4 on its rear axle. The steering 5 is provided at the front axle.

A TV camera 7 or 8 is located at each side of the motor vehicle approximately in the center between the front axle and the rear axle. The camera can be swiveled horizontally around the angle α in order to be able to observe the front wheel 1 or 2 as well as the rear wheel 3 or 4 from two different positions. For the purpose of observation, the circle 6 of each wheel corresponding to the rim diameter is especially highlighted. The respective circle is observed by the camera 7 or 8 from two different positions. For this purpose the TV camera is vertically displaceable by the distance h as shown in figure 2. The distance of the TV camera to the respective wheel or to the center point of the circle 6 can be determined based on the different height positions of the TV camera 8 or 8'.

The TV camera 7 or 8 is arranged in such a way that its optical axis encompasses an angle β of about 45° or more in the straight-forward position of the wheels with the respective wheel axle. When implementing the measurement method according to the invention, the wheel position of the steered wheels, i.e. the front wheels, might have to be changed repeatedly. In the process the angle β is also changed according to the magnitude of the steering angle.

In the case of the exemplary embodiments shown in figs. 1 and 2, the TV cameras 7 and 8 are swivelable and vertically displaceable. This swivelability and displaceability can be eliminated if each wheel is observed with the aid of two cameras mounted on top of each other.

In the case of the exemplary embodiment shown in figure 3, the wheel 4 is observed by means of a stationary TV camera 9 located in housing 10, the optical axis of which runs vertically from the top to the bottom. In order to generate an elliptical image of the rim diameter circle 6 (which is not represented in greater detail) on the light-sensitive layer of the TV pick-up tube, the tilted mirrors 11 and 12 which are arranged in a row in the optical axis of the TV camera 9 are provided. The tilted mirror 11 near the camera can be folded out of the optical axis. In this manner the wheel 4 can be observed from two different levels, either via the tilted mirror 11 or the tilted mirror 12. In order to also be able to observe the front wheel 2 of the chassis shown in figure 1 with the arrangement shown, the tilted mirrors 11 and 12 are located in frame 13 which is rotatable around the optical axis of the TV camera 9. The TV camera is preferably also rotated.

Figure 4 shows the elliptical image 6' of the rim diameter circle 6 of the wheel on the screen 14 of a TV reproducing tube. With the aid of an electronic evaluation circuit of the TV signal, for example, five random points of the elliptical image can be selected and their position determined in an XY coordinate system. The diameters of the ellipsis and thus the position of the center points can be determined based on the coordinates of these five points.

When determining the characteristic data of the elliptical image it is also possible to proceed according to figure 5, according to which only two points as well as two tangents are determined on screen 15 from the elliptical image 6" of a circle corresponding to the rim diameter. Based on the coordinates of the two elliptical points as well as the equations of the two, in this case, horizontal tangents, the large and small diameter of the ellipsis as well as the center point can also be determined.

Figure 6 together with figure 7 are showing an example of how by means of different lenses a single picture element of the elliptical image 6" from the large image 15 can be reproduced in enlarged form in the image section 16 and can thus be measured more accurately. In order to be able to conduct such sectional analysis, it is necessary to equip the camera in question with automatically exchangeable lenses of varying focal points or with a zoom lens.

12 Claims
7 Figures

Summary

Method and Arrangement for Contactless Axle Measurement on Motor Vehicles

For the purpose of contactless measurement of the position of wheel axles and of the steering geometry of a motor vehicle an elliptical image of the circle corresponding to the outer rim diameter of the wheel is generated on a TV pickup tube. The characteristic data of the ellipsis are determined by means of an electronic evaluation of the image signal from the TV pickup tube. Several images are generated and subsequently evaluated by changing the position of the TV camera and, if necessary, the wheel position. The data from the wheel axle and the steering geometry are calculated based on the measurement results by taking into consideration the mathematical relationships (circle-ellipsis affinity, conic section geometry). To conduct the measurements at least one TV camera (7, 8) is located on each side of the motor vehicle (1, 2, 3, 4, 5; 6) approximately in the middle between the front axle and the rear axle which, for example, is horizontally swivelable and vertically displaceable and the optical axis of which encompasses an angle β of about 45° or more with the respective wheel axle when projecting into a horizontal plane (figure 1).

Zm 3 Win/11/23/1979

[Figures]

Subsequently submitted.

[Figures]

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[Handwritten note: Drawings (Fig. 1-7) replaced 1/2/80]

Patent Claims

1. Method for contactless measurement of data from the wheel axle and the steering geometry of a motor vehicle with which an image dependent on the wheel position is generated on the light-sensitive layer of a TV pick-up tube and the image generated is evaluated electronically, characterized in that an elliptical image (6') of the circle (6) corresponding to the outer rim diameter of each wheel or a circle arranged concentrically relative to it and mounted on the wheel rim is generated on the light-sensitive TV pick-up tube, that by means of an electronic evaluation of the image signal from the TV pick-up tube the large and the small diameter of the ellipses, as well as the spatial position of the diameter and its intersection are determined, that in sequence with the same wheel position and possibly with a changed wheel position varying elliptical images of the circle are generated and the image generated in each case is evaluated electronically, and that as a result of the measurement results obtained in sequence as well as by taking into account familiar mathematical relationships, the spatial positions of the wheel plane and of the steering axis are determined electronically and the data of the wheel axle and of the steering geometry are determined from the respective data as well as the stored positional data from the TV pick-up tube and the wheel dimensions.

2. Arrangement to implement the method according to Claim 1 with which alongside the longitudinal axis of the motor vehicle a TV camera is mounted and the electrical components of the TV camera are electrically connected with an electronic image evaluation device, characterized in that on each side of the motor vehicle a TV camera which can be horizontally swiveled and vertically displaced is mounted, the optical axis of which together with the respective wheel axle encompasses an angle of about 45° or more when projecting into a horizontal plane.

3. Arrangement according to Claim 2, characterized in that instead of a vertically displaceable TV camera, two TV cameras are arranged on top of each other.

4. Arrangement according to Claim 2, characterized in that instead of one TV camera swivelable in two positions, two TV cameras are arranged in a stationary fashion.

5. Arrangement to implement the method according to Claim 1 with which alongside the longitudinal axis of the motor vehicle a TV camera is mounted and the electrical components of the TV camera are electrically connected with an electronic image evaluation device, characterized in that on each side of the motor vehicle a TV camera is arranged with a tilted mirror displaceable in its optical axis or with two tilted mirrors arranged in a row in its optical axis of which the mirror near the camera can be folded out of the optical axis and that the tilted mirror or mirrors, individually or jointly, are rotatable around the optical axis of the TV camera in such a way that the optical axis of the TV camera reflected by the tilted mirrors encompasses an angle of about 45° or more with the respective wheel axle when projecting into a horizontal plane.

6. Arrangement according to Claim 5, characterized in that the camera together with the tilted mirrors is rotatable around the optical axis incrementally by small angles, for example by an angle of about 1°.

7. Arrangement according to Claim 5, characterized in that the deflection angle of the tilted mirrors is adjustable incrementally by small angles, for example by an angle of about 1°.

8. Arrangement according to one of the Claims 2 through 7, characterized in that the TV camera (8) is (are) arranged on each side of the motor vehicle, approximately in the center between the front axle and the rear axle.

9. Arrangement according to one of the Claims 2 through 8, characterized in that the respective TV camera is provided with automatically exchangeable lenses of varying focal points or with a zoom lens.

10. Arrangement according to one of the Claims 2 through 9, characterized in that the respective TV camera and/or the tilted mirrors are equipped with a precision positioning device acting in a horizontal or vertical plane.

11. Modification of the method according to Claim 1, characterized in that the respective wheel is illuminated with a laser beam line by line, and that the reflected light is received and the received light signal is electronically evaluated together with the pulses controlling the laser beam.

12. Modification of the arrangement according to one of the Claims 2 through 7 to implement the method according to Claim 11, characterized in that each TV camera is replaced by a laser tube with a laser beam deflection system and one light-sensitive diode oriented toward the respective wheel.